MORTALITY AMONG EMPLOYEES OF SLATER STEELS HAMILTON SPECIALTY BAR DIVISION HAMILTON, ONTARIO

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EXECUTIVE SUMMARY

In November 1987, the Minister of Labour received a letter from the Health and Safety Coordinator of the United Steel Workers of America who expressed concern about a perceived high rate of lung cancer among employees of the Sherman Avenue plant of Slater Steels in Hamilton. In reply, the Minister promised that Ministry of Labour officials would meet with the Joint Health and Safety Committee at the plant to further explore their concerns. This meeting took place on January 25, 1988.

The Health and Safety Committee expressed anxiety about the occurrence of cancer in the Melt Shop area of the plant. It was agreed at the meeting that the Ministry of Labour would undertake an exploratory study to determine whether the cancer experience of Slater Steels employees was indeed different from the Ontario average. It was decided that the most rapid method of reaching an answer would be to carry out an analysis of the mortality pattern of those deaths which could be identified from Company files. Since information in the scientific literature indicated that workers in the steel and foundry industries had, historically, been at increased risk of lung cancer, the major question to be addressed by the investigation was whether men who had worked in the Melt Shop at Slater Steels had experienced an increased risk of lung cancer. This report presents the results of the analysis.

The basic method adopted for this study was that of Analysis of Proportional Mortality, supplemented by internal comparisons using case-control methodology. This approach is convenient for an exploratory analysis because one may make use of mortality information from Company pension and employment files without the expensive and time-consuming process of tracing employees who have left employment. The Human Resources Department at Slater Steels provided the names of deceased workers who were pensioners or active employees at the times of their deaths. The earliest deaths so identified were

the deaths of 2 pensioners in 1968, while the earliest date found for the death of an active worker was 1973. Causes of death were determined by the Ministry of Labour by locating the death certificates of the deceased workers.

The Human Resources Department at Slater Steels provided the names of 147 deceased former employees. Information about the causes of death could not be located for 6 of these men who had died outside of Ontario, and they were excluded from the study. Among the remaining 141 men were 102 retirees and 39 men who were classified as active employees at the times of their deaths.

The analysis of mortality found that, in comparison with the general population of Ontario, retirees experienced a lower proportion of deaths from cancer while active employees had a slightly higher proportion of deaths from cancer. As far as lung cancer was concerned, retirees again experienced a lower proportion of deaths from lung cancer, while the proportion of lung cancer deaths among active employees was doubled. The only other noteworthy finding was increased mortality from cirrhosis of the liver among both groups.

The next step in the analysis was to investigate mortality patterns according to work area, making use of work histories provided by the Human Resources Department. Work histories could not be located for 10 of the 141 men and these individuals were consequently excluded from the analysis of mortality according to work area, leaving a total of 131 men. In considering the relationship between workplace exposures and death from cancer, it is reasonable to assume that exposures occurring shortly before death were unlikely to be the cause of the tumour. All job assignments within 5 years of death were thus excluded from consideration.

Twenty-three men had worked in the Melt Shop while 108 had not. In comparison with the general population of Ontario, the proportion of deaths from cancer was diminished among the men without Melt Shop exposure, while there was a small excess

(9 observed, 5.8 expected) among the men who had worked in the Melt Shop. This cancer excess was attributable to increased mortality from lung cancer, from which there was a 3-fold excess among Melt Shop workers. In contrast, the proportion of deaths from lung cancer was lower than the Provincial average among men without Melt Shop exposures. For no other type of cancer was the proportion of deaths substantially different from expectation.

Comparison of the lung cancer experience of the Slater population with the general population of Ontario could be misleading because Slater workers might differ from the general population with respect to various risk factors for lung cancer, such as cigarette smoking habits and urban residence. It would be expected, however, that Slater employees working in different areas of the plant would not differ greatly on non-occupational risk factors for lung cancer. Since 108 of the 131 men had never worked in the Melt Shop it was possible to directly compare the cancer risk of Slater employees working in the Melt Shop with the risk among men working in other areas of the plant.

Detailed analysis was restricted to men who died between the ages of 45 and 75 because no younger men died of lung cancer and because only one man who died at an older age had worked in the Melt Shop. Employment in the Melt Shop was strongly associated with an increased risk of lung cancer. It was estimated statistically that, in comparison with men who had never worked in the Melt Shop, men who had worked in the Melt Shop had a risk of lung cancer that was increased 6-fold.

Continuous Casting operations began in July, 1968 and introduced a major change in process as ingots were no longer cast in fixed moulds. To assess lung cancer risk associated with employment prior to the introduction of Continuous Casting an analysis was performed in which only that employment time spent in the Melt Shop before August, 1968 was counted as exposed time. The results of the analysis were essentially the

same as the one in which all employment time in the Melt Shop was counted, indicating that essentially all of the risk might be attributable to exposures occurring prior to the introduction of Continuous Casting.

The relevance of the findings of this study for current employees at the plant is uncertain because the lung cancer risk might be attributable to exposures occurring prior to the introduction of Continuous Casting. The workers at highest risk were the Pitmen and the Crane Operators, who would have had the greatest exposure to fumes rising from the moulds heated by the molten steel. Even though a number of studies have found increased lung cancer risk among workers in the steel and foundry industries, the causative agent or agents have not yet been identified. One class of chemicals being considered by scientists are the organic combustion products, the Polycyclic Aromatic Hydrocarbons(PAH). In addition, a number of metals such as cadmium and nickel are suspected of being capable of causing cancer in humans. In follow up to the present analysis, it is suggested that an inventory of airborne contaminants currently in the plant atmosphere be compiled and examined for the presence of known or suspected cancer-causing agents.

Environmental conditions in the plant have changed considerably in the past 20 years. The Continuous Casting process has been introduced. Ventilation has been improved and baghouses have been added. Crane operators now work in air conditioned enclosures. It is not possible with the data collected for this exploratory study to determine whether any lung cancer risk exists for those who began work in the Melt Shop after 1968. All but one of the men dying of lung cancer had some exposure prior to 1968, and it generally takes 15 or more years for occupational cancers to develop. For the moment, the assessment of current Melt Shop conditions will have to rely upon environmental analyses and a subjective comparison with previous conditions. It is recommended that

the Joint Health and Safety Committee review the changes in the plant with Ministry of Labour hygienists in an effort to determine to what extent hazardous airborne exposures might exist in the Melt Shop.

Surviving Melt Shop employees who were exposed during the same time period as the workers in this study are presumably at increased risk of developing lung cancer. It would be desirable to offer an intervention to lessen the danger, but no medical procedure is known which will lessen the risk. It has been shown that neither screening with periodic chest X-rays nor screening with sputum cytology lessens mortality rates from lung cancer. The only action which is believed to be worthwhile is SMOKING CESSATION. It is thus recommended that an attempt be made to advise current and former Melt Shop workers of the lung cancer risk and to strongly urge them to stop smoking. It is recommended that consideration be given to compiling a roll of former employees for the purposes of issuing the smoking advisory and of carrying out an expanded mortality study.

An unanticipated finding in this study was the increased proportion of deaths related to alcohol abuse. Eight deaths were directly attributed to cirrhosis or acute alcohol intoxication, and in 3 other instances alcohol-related causes were listed on the death certificate as contributing causes of death. Alcohol abuse markedly shortened the lives of those affected; the average age at death was 55 years. The average loss of life expectancy was 16.8 years for lung cancer and 22.3 years for alcohol-associated deaths. Clearly, much is to be gained by preventing alcohol-associated disease.

As a result of the exploratory analysis of mortality among employees of Slater Steels, the following actions are recommended to the Joint Health and Safety Committee:

1) It is recommended that the Joint Health and Safety Committee review, with Ministry of Labour hygienists, environmental changes in the Melt Shop in an effort to determine if hazardous airborne exposures exist at present. It is suggested that an inventory of airborne contaminants be compiled and examined for the presence of known or suspected cancer-causing agents.

2) It is recommended that an attempt be made to advise current and former Melt Shop workers of the lung cancer risk and to strongly urge them to stop smoking.

3) It is recommended that the Joint Health and Safety Committee explore ways in which illness due to alcohol abuse can be prevented. The potential savings in human health and disability would appear to be great.

4) It is recommended that consideration be given to an expanded study of mortality for the purpose of better defining the lung cancer risk among current and former employees.

INTRODUCTION

In November 1987, the Minister of Labour received a letter from the Health and Safety Coordinator of the United Steel Workers of America who expressed concern about a perceived high rate of lung cancer among employees of the Sherman Avenue plant of Slater Steels in Hamilton. In reply, the Minister promised that Ministry of Labour officials would meet with the Joint Health and Safety Committee at the plant to further explore their concerns. This meeting took place on January 25, 1988.

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AN OVERVIEW OF THE HISTORY OF THE HAMILTON SPECIALTY BAR DIVISION OF SLATER STEELS

The Company was founded in 1910 as the Canada Steel Company for the purpose of manufacturing steel bars and shapes rolled from used railroad rails. In 1914 the company was renamed Burlington Steel Company. Until 1935, the process was restricted to the processing of rail steel products produced on the Rolling Mill on a one-shift basis. In 1935, a second shift was introduced in the Rolling Mill and a 5-ton Electromelt furnace was installed to augment the steel supply to the Mill and to provide special purpose steels. In 1961, control of the Company was taken over by N. Slater Company, Limited.

In 1964, a new 20 ton Heroult melt unit and a 40 ton crane were installed in a new Melt Shop building. Operation of the 5 ton Electromelt unit was discontinued. In 1965, a second 20 ton Heroult melt unit was installed in the Melt Shop and a second 40 ton crane was erected. In 1967, the use of rails as a source of raw materials was discontinued. Also in 1967, the installation of a third Heroult melt unit was begun and a 70-ton overhead crane was installed. Operation of the new unit began in February, 1968 and at the same time the Melting Furnaces were equipped with a 72,000 c.f.m. fume exhaust system and a bag house dust recovery system. In October, 1968 operations were scheduled for 3 crews and 15 shifts per week.

A 3-strand Concast continuous steel billet casting machine began operations in July, 1968. A second 3-strand Concast machine was completed and put into operation in May, 1970.

An additional fume exhaust and bag house dust recovery system, rated at 160,000 c.f.m. was installed in 1971 to supplement the existing system. In August, 1974 the two 20 ton melting furnaces were changed to split shells which required less down time when repairs were required.

During the period 1974-1978, changes to the Melt Shop and Rolling Mill were made for the introduction of special bar

quality and alloy grades. In 1974, a process was introduced for the shielding of the tundish stream with nitrogen. In 1976, an aluminum wire addition process was finalized for the production of aluminum fine grain billets. In 1976, a new 90 ton heat crane was installed in the Melt Shop. In 1977 the ladle stream shrouding process was developed using a ceramic submerged shroud. In 1977, boron steels for high and medium carbon grades were developed.

After one year of trials with Foseco boards, as opposed to the conventional lining method, an improved Foseco Tundish Handling System was implemented in April 1979. The Foseco system presented an advantage in that the need for tundish lancing was obviated and the consequent fume emission in and from the Melt Shop was eliminated. The system also moved the dumping of tundishes, with its associated heat and dust, outside the Melt Shop building and further improved the working environment in the Shop.

In August 1979, the Melt Shop converted from a stopper rod system in the ladle to a slide gate system. In April 1980, water cooled panels at 'C' furnace were installed, resulting in decreased refractory usage and increased furnace operating time.

In November, 1981 installation was completed on a "Catco" system (air conditioning-heating) for Melt Shop crane cabs. The system provided for better filtration through its use of outside air and for the provision of fresh air from the outside in the event of air conditioning breakdown.

In August, 1982 a new 15,000 lb capacity charging machine was purchased for 'C' furnace to replace the 6000 lb capacity charging machine. This improved working conditions through reduction of the necessity to shovel additions during outages.

In March, 1983 a carbon injection system was implemented on 'A', 'B', and 'C' furnaces. The system allowed for injection of carbon and other alloys directly into the bath. Prior to the installation, additions of carbon into the furnace

had been done by adding the carbon with the first and second charges and by dipping electrodes during refining.

In November, 1985, the installation of a ladle refining reheating furnace was completed at the site of the old 'B' furnace. The ladle furnace was designed for secondary steelmaking involving arc reheating and alloying of up to 66 ton heats of steel contained in treatment ladles.

Employment records for the years 1967 through 1987 indicate average staffing levels ranging from 620 to 824 employees. Annual man-hours worked ranged from 1.2 million to 1.5 million.

HEALTH HAZARDS IN STEELMAKING

Some lung cancers are thought to be connected with carcinogens in the fumes produced in steelmaking[1]. A case-control study was undertaken in Pennsylvania to investigate occupational determinants of lung cancer in an area with a sizeable steel manufacturing industry[2]. This study evaluated the risk of lung cancer among a large steel workforce while controlling for smoking and other factors. The next-of-kin of 335 men dying of lung cancer and 332 men dying of other diseases were interviewed to obtain occupational and personal histories. The relative risk of lung cancer associated with employment in the steel industry was 1.7 with a 95% confidence interval of (1.4, 2.1). The excess risk was primarily among men who had spent 15 or more years in steel manufacture; relative risk 2.2 (1.5, 3.3). The relative risk associated with shorter employment periods (6 months to 15 years) was elevated at 1.3, but was not statistically significant, the 95% confidence interval being (0.9, 1.8). The increased risk associated with long-term steel employment was not attributable to cigarette smoking, although adjusting for smoking lowered the relative risk for steelmaking from 2.2 to 1.8, 95% confidence interval (1.2, 2.8). The relative risks were highest among men who worked in areas near the furnace, open hearth, forge, or rolling mills; in foundries, and in administrative jobs.

Although Slater Steels is not a foundry operation, there were some processes in common with the foundry industry, such as the melting of ferrous metals and pouring into moulds. Health studies of foundry workers might thus provide some information relevant to the health of Slater workers. A number of epidemiological studies in the past decade have shown foundry workers to be at increased risk of lung cancer. Koskela and colleagues[3] studied the mortality experience of 3800 workers from the foundry sector in Finland. Twenty-one

workers died of lung cancer compared with an expectation of 14. Lung cancer mortality was higher in iron foundries than in foundries of other types. This study was followed by a Finnish case-control study[4] of 3425 iron foundry workers in an effort to determine causative factors in the foundry environment. Attention was focused on the polycyclic aromatic hydrocarbons(PAH), but measurements performed in foundries did not reveal great differences among the exposures of different occupational groups; all groups had some exposure to PAHs. An association was found between the estimated extent of exposure to PAHs and the risk of lung cancer, but this association was not statistically significant.

Gibson and colleagues[5] studied lung cancer mortality at DOFASCO, a steel foundry in Hamilton. The study group consisted of all employees and retirees who were 45 years of age or older - 1542 individuals. A hygiene survey was undertaken in conjunction with this analysis, specifically to measure levels of particulates, the benzene soluble fraction of total suspended particulates, and metals. All employees were assigned to a "foundry" or "non-foundry" group depending upon whether or not they had spent more than 5 years in the foundry. The relative risk, comparing foundry to non-foundry workers, was elevated 5-fold for lung cancer, but was not significantly increased for total cancer mortality or for deaths from all causes combined. In this factory, crane operators had the greatest increase in risk. In order to identify causative factors, additional environmental testing was performed[6]. Initial analysis was not particularly helpful. Four known PAH carcinogens were identified; the concentrations were quite low and did not indicate any gradation between foundry areas. Inorganic material was measured in trace amounts or at levels well within accepted guidelines.

Decoufle and Wood[7] studied mortality among workers at a gray iron foundry that was an integral part of a large

industrial plant in a northern U.S. city. The study group was derived from the male work force of the entire plant who had accumulated at least one year employment in "blue collar" jobs prior to 1968. Among 24,000 men meeting these criteria, 2861 had worked in the foundry for at least one month and were included in the study cohort. The number of men who had spent any substantial time in the foundry and who had a sufficiently long follow-up interval was small and a small excess of lung cancer was observed among them.

Egan-Baum and colleagues[8] performed a proportional mortality study of deaths occurring among members of the International Molders and Allied Workers Union using records maintained by the Union. Death certificates of 2990 foundry workers were analyzed. Increased proportional mortality due to lung cancer and non-malignant respiratory disease was observed.

To follow-up the observation of lung cancer excess among DOFASCO workers, Fletcher and Ades[9] carried out a large cohort study for the Steel Castings Research and Trade Association in England. The cohort was comprised of 10,250 workers who were employed for at least one year in one of 9 English steel foundries. There was significantly increased lung cancer mortality among men with foundry and fettling shop occupations. As with the other studies described above, smoking data was not available.

Silverstein and colleagues[10] performed a proportional mortality analysis of deaths occurring among 278 male hourly workers who were employed for at least 10 years at an American gray iron foundry. There was a significant excess proportional mortality due to lung cancer.

STUDY METHODS

The basic method adopted for this study was that of Analysis of Proportional Mortality, supplemented by internal comparisons using case-control methodology. This approach is convenient for an exploratory analysis because one may make use of mortality information from Company pension and employment files without the expensive and time-consuming process of tracing workers who have left employment. Using this method, the relative frequency of deaths from various causes occurring in the Slater population were compared with the pattern of deaths occurring in the general population of Ontario. In particular, we wished to compare the percentage of all deaths among Slater workers that was due to lung cancer with the percentage of lung cancer deaths occurring among men of the same ages in the whole of Ontario. Provincial statistics indicate that from 1970-1974, for example, 0.5% of men who died between the ages 25-34, 3.8% of men who died between the ages of 35-44, 6.7% of men dying between 45-54, and 8.9% of men dying between 55-64, died from lung cancer. Given the ages and dates of death of Slater employees, a computer program[11] computed the proportion of lung cancer deaths one might have expected to see among Slater workers if their experience were identical to the Ontario average. There are important limitations to this method, and they will be discussed later in the report.

A) INFORMATION USED IN THE ANALYSIS

The Human Resources Department at Slater Steels provided the names of deceased employees obtained from Pension files and employment records. Availability of this information was limited to men who were pensioners or active employees at the time of death. The earliest deaths so identified were the deaths of 2 pensioners in 1968. The earliest date found for

the death of an active worker was 1973. Causes of death were determined by the Ministry of Labour by locating the death certificates of these men.

The Human Resources Department also supplied job histories for the deceased employees, permitting a comparative analysis of mortality by occupation.

RESULTS

1) MEN IN THE STUDY POPULATION

The Human Resources Department provided the names of 147 deceased former employees. Information about the causes of death could not be located for 6 of these men who had died outside of Ontario, and they were excluded from the study. Of the remaining 141, death certificates were located for 137 men and physicians' reports to the life insurance carrier were used to determine the causes of death for 4 others who had died in the United States. None of these latter 4 deaths was attributed to cancer. Among the 141 men in the analysis were 102 retirees and 39 men who were classified as active employees at the times of their deaths.

2) DISTRIBUTION OF CAUSES OF DEATH COMPARED WITH THE ONTARIO AVERAGE

Table 1 presents the results of the comparison of the causes of death in the Slater Steels population with those occurring among men of similar ages in the Ontario population. In reading this Table it should be noted that the "Expected Number" of deaths from Cause "A" is derived by multiplying the total number of deaths in the Slater population by the fraction of all deaths that are due to Cause "A" among men of similar ages in the Ontario population. For example, the proportion of deaths due to Cancer among men in the Ontario population who were of the same ages as the Slater retirees was 23%. The "Expected Number" of Cancer deaths among Slater retirees was accordingly the Total Number of Deaths (102) times 23% = 23.8 deaths. The "Observed Number" of Cancer deaths among the retirees was actually 16. The Proportional Mortality Ratio (PMR) is defined as 100 times the ratio "Observed/Expected". The PMR will be equal to 100 if the Slater experience was the

same as the Provincial average, will be greater than 100 if the proportion of deaths from Cause "A" among Slater workers was higher than the Provincial average, and the PMR will be less than 100 if the proportion of deaths from cause "A" among Slater workers was less than the Provincial average. In this instance, the PMR is 100 x (16/23.8) = 67, which indicates that the proportion of deaths which was due to Cancer was smaller among Slater retirees than it was in the General Population. The situation was reversed for the active employees, for whom the Cancer PMR was 125.

Turning to specific cancer sites, the Table indicates that deaths from lung cancer were slightly fewer than might have been expected among the retirees, but that the PMR was doubled among active employees. The increased proportion of lung cancer deaths among active employees (7 observed versus 3.3 expected) was statistically significant.

The only other cancer sites which were found in excess were cancers of the Urinary System (Kidney and Bladder) among active workers, but the numbers were very small, with only 2 cases observed compared with an expectation of 0.5.

Turning to non-cancer causes of death, the proportion of deaths from Circulatory Diseases, the major causes of death in Ontario, was essentially the same as in the general population. There was a slight excess in the proportion of retirees dying from respiratory diseases, but there were no deaths from these causes among the active workers. The only other cause of note is Cirrhosis of the Liver, for which the PMR was increased for both active and retired men.

3) MORTALITY COMPARISON ACCORDING TO EMPLOYMENT AREA

The Joint Health and Safety Committee was concerned that there was an excess number of cancer cases among employees

working in the Melt Shop. In addition, there was scientific information to indicate that steel workers might be at increased risk of lung cancer. The next step in the analysis was thus to investigate mortality patterns according to work area, making use of work histories provided by the Human Resources Department.

Work histories could not be located for 10 of the 141 men and these men were consequently excluded from the analysis of mortality according to work area, leaving a total of 131 men in this analysis. Only one of the men excluded died of cancer, and that was a cancer of the bowel. In considering the relationship between workplace exposures and death from cancer, it is reasonable to assume that exposures occurring shortly before death were unlikely to be the cause of the tumour. All job assignments within 5 years of death were thus excluded from consideration.

For the analysis presented in Table 2, the 131 men were classified according to whether or not they had ever worked in the Melt Shop (excluding the period 5 years before death). Twenty-three men had Melt Shop exposures, while 108 had none. In comparison with the general population of Ontario, the PMR for All Cancers was 67 among men without Melt Shop exposure, while there was a small excess (9 observed, 5.8 expected) among men who had worked in the Melt Shop. This cancer excess was attributable to increased mortality from lung cancer, from which there was a 3-fold excess among Melt Shop workers. In contrast, the proportion of deaths from lung cancer was lower than the Provincial average among men without Melt Shop exposures.

For no other type of cancer was the proportion of deaths substantially different from expectation. Among the non-cancer causes of death, Cirrhosis of the Liver once again stands out, and is in excess among both Melt Shop and non-Melt shop workers.

4) FACTORS DETERMINING LUNG CANCER RISK WITHIN THE SLATER POPULATION

A) Melt Shop Employment

Comparison of the lung cancer experience of the Slater population with the general population of Ontario could be misleading because Slater workers might differ from the general population with respect to various risk factors for lung cancer, such as cigarette smoking habits and urban residence. It would be expected, however, that Slater employees working in different areas of the plant would not differ greatly on non-occupational risk factors for lung cancer. Since 108 of the 131 men had never worked in the Melt Shop it was possible to directly compare the cancer risk of Slater employees working in the Melt Shop with the risk among men working in other areas of the plant.

One important factor pertaining to lung cancer risk in Ontario is age. Table 3 shows the lung cancer pattern in the Slater workforce according to the workers' ages at death. This Table gives the proportion of deaths from lung cancer in each age group according to whether or not the worker had held a job in the Melt Shop. It should first be noted that lung cancer is rare in young men and that there were no lung cancer deaths among men less than 45 years of age (the youngest man dying of lung cancer was 49 years). Secondly, only 1 of the 38 men who died at ages of 75 or more had ever worked in the Melt Shop. In order to assess the risks of Melt Shop employment it is thus appropriate to restrict attention to men who died between the ages of 45 and 75.

The Table shows that among men who died between the ages of 45 and 64, 6(55%) of the 11 men who had ever worked in the Melt Shop died of lung cancer compared with 4(10%) of the 39 men who had never worked in the Melt Shop. Among men between 65 and 74 years of age, 1(14%) of 7 men who had ever worked in the Melt Shop died of lung cancer compared to none of 28 who

had never worked in the Melt Shop. Figure 1 illustrates these proportions.

The risk of lung cancer is clearly higher among the men with Melt Shop exposures. A quantitative estimate of the comparative risk, averaging the 2 age ranges, was obtained using the statistical technique known as Conditional Logistic Regression[12]. It was thus estimated (Table 4) that among former Slater employees who died between the ages of 45 and 74, the risk of death from lung cancer was 6.9 times higher among men who had ever worked in the Melt Shop than among Slater employees who had never worked in the Melt Shop. The number of deaths is very small, from a statistical point of view, and the size of the risk estimate would change substantially if there were one death more or less in any of the exposure categories. This "instability" in the Risk Estimate is quantified by a statistical measure known as the Confidence Interval. Because of the small numbers involved in the calculation, the 95% Confidence Limits for the risk factor are very broad, ranging from 1.3 to 36.9; that is, there is a 95% probability that the true increase in lung cancer risk lies somewhere between a 1.3-fold and 36.9-fold increase in risk among Melt Shop workers compared with other Slater employees.

In order to further quantify risk in the Melt Shop, the length of time worked in Melt Shop occupations was computed by summing the number of days spent in the various jobs, with a cut-off 5 years before the date of death. Table 4 gives estimates of the risk of death from lung cancer, according to the number of years employed in the Melt Shop, for men dying between the ages of 45 and 75. There is a strong trend in lung cancer risk with the length of employment in the Melt Shop. Compared to men without Melt Shop exposures, men with 6 months to 5 years employment in the Melt Shop had their risk of lung cancer increased 6-fold, while men with more than 5 years employment in the Melt Shop had their lung cancer risk increased 13-fold. Once again the Confidence Intervals are

very broad and there is a wide margin of uncertainty about the exact size of the increased lung cancer risk.

Continuous Casting operations began in July, 1968 and introduced a major change in process as ingots were no longer cast in fixed moulds. It is possible that chemicals in the moulds were associated with the risk of cancer. An analysis was thus performed in which only that employment time spent in the Melt Shop before August, 1968 was counted as exposed time. Three men, including one lung cancer victim, were employed in the Melt Shop only after the introduction of Continuous Casting, and are thus classified as "Never Melt Shop Workers" in this particular analysis. The results of the analysis are presented in Table 5, and are essentially the same as the results of Table 4, indicating that essentially all of the risk might be attributable to exposures prior to the introduction of Continuous Casting.

The Continuous Casting Department is in the same building as the Melt Shop and is not isolated from it. One thus wonders about the risk of lung cancer among workers with employment in Continuous Casting. It happens that only 5 men in the study population had ever worked in this area. One of them died of lung cancer, but he had also worked in the Melt Shop. It can thus not be determined in this analysis whether there has been any lung cancer risk associated with employment in the Continuous Casting Department.

B) Jobs in the Melt Shop

In order to determine which exposures might have been responsible for the increased lung cancer risk, and to assess whether or not conditions might still be dangerous, it is important to know what jobs were associated with the lung cancer hazard. Table 6 lists the jobs held by the Melt Shop employees who died of lung cancer. These jobs were: Pitman, Crane Operator, Ladleman, Furnaceman, Labourer, Tundish Conditioner, and Mould Inspector. A brief description of these

jobs follows.

1) Pitman:

Prior to Continuous Casting, the steel was poured into moulds. It was the job of the Pitman to pull the red hot ingots out of the moulds. This job was eliminated in the late 1960s.

2) Crane Operator:

The crane operators drop the charge of scrap metal into the furnace or transport the ladle of molten metal from the furnace to the pouring area. For the past 8 years the crane operators have worked in ventilated enclosures provided with air from outside the Melt Shop.

3) Ladleman:

The ladleman used to open the ladles manually for pouring. The ladleman is now in a booth and the opening of the ladles has been automated.

4) Furnaceman:

The furnaceman added materials to the alloy mixture in the furnace and was also present beside the furnace when the molten metal was tapped out.

5) Tundish Conditioner:

The tundish conditioner prepared the tundish to receive the molten metal. He installed the board liners backed by silica. The silica has now been replaced by olivine sand.

6) Mould Inspector:

The mould inspector inspected the moulds used to receive the molten metal in the casting area.

It can be seen in Table 6 that a number of men held more than one of these jobs. The initial risk analysis will, however, examine each job independently. The results are presented in Table 7. The Confidence Intervals in these analyses are very wide because of the small numbers in the computations.

Two(40%) of the 5 men who had ever worked as Crane Operators died from lung cancer, compared with 9(11%) of 80 men who had never held this job. The relative risk of lung cancer for Crane Operators is estimated by the Fisher Exact Test[13] to be 5.3 with the 90% Confidence Interval 1.2 - 38.

All 3(100%) of the Pitmen died of lung cancer, compared with 10% of the men who had never worked as Pitmen. The Relative Risk cannot be computed because the calculation involves division by 0.

Three(60%) of 5 men who had worked as Ladlemen died from lung cancer compared to 10% of men who had never held this job. The relative risk of lung cancer for Ladlemen is estimated by the Fisher Exact Test to be 13.5, with the 90% Confidence Interval ranging from 1.9 - 110.

Two(67%) of 3 men who had worked as Furnacemen died from lung cancer compared to 11% of men who had never held this job. The relative risk of lung cancer for Furnacemen is estimated by the Fisher Exact Test to be 16.2 with the 90% Confidence Interval ranging from 1.3 - 83.

One man who had worked as a Tundish conditioner died from lung cancer, as did one man who had worked as a Mould Inspector. No other men in the study population had worked at these jobs.

Since a number of men had worked at more than one job in the Melt Shop, an attempt was made to separate the risks of the various jobs using a statistical procedure, known as Unconditional Logistic Regression[13], in which the various jobs are examined simultaneously in a mathematical model. In

this analysis, both the Pitman and Crane Operator jobs remained strongly associated with lung cancer risk. As before, the risk for Pitmen could not be quantified because all the men who had worked as Pitmen died from lung cancer; the Relative Risk for Crane Operators was estimated to be 9.2, with a 90% Confidence Interval from 1.7 to 50. Since one of the Ladlemen had also worked as a Pitman, the job "Ladleman" was less strongly associated with lung cancer risk in the combined analysis than in the analysis which examined "Ladleman" by itself. The Relative Risk for Ladlemen was estimated to be 6.9, with a 90% Confidence Interval from 0.8 to 61. Both Furnacemen who died from lung cancer had also worked as Pitmen, and in the combined analysis the job "Furnaceman" was no longer independently associated with lung cancer risk. It must be emphasized that the statistical results are very unstable because the numbers in the analysis are so small.

5) Other Cancer Sites

The only other sites at which there was any indication of possible excess mortality were cancers of the Urinary System; three cancers of the kidney and bladder were observed, with 1.5 expected based upon proportionate mortality in the general population. One man died from kidney cancer following a career as a machinist in the Maintenance Department. Two men died from bladder cancer. One had spent 26 years in the Finishing Department as a Bending Machine and Stock Shears Operator before ending his career as a Stores Clerk. The other man began work at Slater Steels 19 years before his death; he first worked as a Hooker in the Yard and then became a Janitor in the Finishing Department. Given the few deaths and the variety of jobs held by the men dying from urinary cancers, the most probable explanation for the increased proportion of deaths due to these causes is CHANCE rather than any occupational exposures.

6) Alcohol-Related Deaths:

An unanticipated finding was the increased proportion of deaths related to alcohol abuse. Eight deaths were directly attributed to cirrhosis or acute alcohol intoxication, and in 3 other instances alcohol-related causes were listed on the death certificate as contributing causes of death. Alcohol markedly shortened the lives of those affected; the average age at death was 55 years.

It is instructive to compare lung cancer and alcohol-related deaths with respect to life-shortening among Slater employees. There were 13 deaths from lung cancer and 11 alcohol-related deaths. The men dying of alcohol-related deaths were younger, with an average age of 55 years compared to the average age of 63 years among the men dying from lung cancer. There were a total of 219 years of life-shortening among men dying from lung cancer compared to a total of 245 among those dying of alcohol-related causes. The average loss of life expectancy was 16.8 years for lung cancer and 22.3 years for alcohol-associated deaths. Clearly, much is to be gained by preventing alcohol-associated disease.

DISCUSSION

An exploratory study of mortality patterns among Slater Steels employees suggests that men who had worked in the Melt Shop experienced an increased risk of death from lung cancer in comparison with Slater employees who had worked in other areas of the plant. There are a number of methodologic issues worthy of discussion.

The information used in this study pertained only to men who were known, by the Human Resources Department, to have died since 1968. Any deaths occurring earlier, and any deaths occurring among men who had separated from the Company without a pension, were not included in this analysis. The quantitative estimates of the risk of Melt Shop employment might well be altered if men who had left employment are traced in a follow-up to this analysis.

The Proportional Mortality Analysis compared the relative frequency of death from particular causes in the Slater and Ontario populations. Since the Grand Total of proportions must be 100%, a distorted picture of the risk of lung cancer may be obtained if other major causes of death differed between the Slater and Ontario populations. If for example, Slater employees had healthier hearts and died less frequently of heart disease, then the relative frequency of cancer deaths would appear to be greater, even if the risk of cancer were actually the same as in the general population. Using Figure 1 to illustrate this concept, suppose that the "slice of the pie" for "Other Causes" were smaller because Slater employees had healthy hearts, then in order to fill up the "pie", the slice for "lung cancer" would have to be larger. In drawing conclusions from the PMR analysis, it has been assumed that the Slater employees had a mortality pattern similar to the Ontario average for the major causes of death.

A major benefit in this study was the opportunity to compare the cancer experience of Melt Shop workers with that of

other Slater employees. Cigarette smoking is the major cause of lung cancer in Ontario, and information about the smoking habits of Slater employees was not available. It is not anticipated that the smoking patterns of the workers would be associated with their job locations, and so the difference in lung cancer risk between Melt Shop and other employees is likely to be related to occupational exposures rather than to differences in smoking habit.

The relevance of these findings for current employees at the plant is uncertain. As demonstrated in Tables 4 and 5, the lung cancer risk might be attributable to exposures occurring prior to the introduction of Continuous Casting. The workers at highest risk were the Pitmen and the Crane Operators, who would have had the greatest exposure to fumes rising from the moulds heated by the molten steel. Even though a number of studies have found increased lung cancer risk among workers in the steel and foundry industries, the causative agent or agents have not yet been identified. One class of chemicals being considered by scientists are the organic combustion products, the Polycyclic Aromatic Hydrocarbons(PAH). In addition, a number of metals such as cadmium and nickel are suspected of being capable of causing cancer in humans. In follow up to the present analysis, it is suggested that an inventory of airborne contaminants currently in the plant atmosphere be compiled and examined for the presence of known or suspected cancer-causing agents.

Environmental conditions in the plant have changed considerably in the past 20 years. The Continuous Casting process has been introduced. Ventilation has been improved and baghouses have been added. Crane operators now work in air conditioned enclosures. It is not possible with the data collected for this exploratory study to determine whether any lung cancer risk exists for those who began work in the Melt Shop after 1968. All but one of the men dying of lung cancer had some exposure prior to 1968, and it generally takes 15 or

more years for occupational cancers to develop. For the moment, the assessment of current Melt Shop conditions will have to rely upon environmental analyses and a subjective comparison with previous conditions. It is recommended that the Joint Health and Safety Committee review the changes in the plant with Ministry of Labour hygienists in an effort to determine if extent hazardous airborne exposures exist at present in the Melt Shop.

It seems likely that men who were employed in the Melt Shop during the same time as the men included in this analysis are also at increased risk of lung cancer. It is recommended that consideration be given to compiling a roll of current and former employees for the purpose of carrying out an expanded study of mortality.

CONCLUSIONS

An increased risk of lung cancer has been detected among men who were employed in the Melt Shop at Slater Steels. It is not possible with the data collected for this exploratory study to determine whether any lung cancer risk exists for those men who began work in the Melt Shop only after 1968. For the moment, the assessment of current Melt Shop conditions will have to rely upon environmental analyses and a subjective comparison with previous conditions.

Surviving Melt Shop employees who were exposed during the same time period as the workers in this study are presumably at increased risk of developing lung cancer. It would be desirable to offer an intervention to lessen the danger, but no medical procedure is known which will lessen the risk. It has been shown that neither screening with periodic chest X-rays nor screening with sputum cytology lessens mortality rates from lung cancer. The only action which is believed to be worthwhile is SMOKING CESSATION. Among asbestos workers who stopped smoking, the risk of lung cancer was 1/3 of the risk among men who continued to smoke[14]. Other studies have shown that after 15 years as a non-smoker the risk fell to about double the risk among never-smokers[15]. It is thus recommended that an attempt be made to advise current and former Melt Shop workers of the lung cancer risk and to strongly urge them to stop smoking.

An unexpected finding in this analysis was the toll taken by alcohol-related diseases in the workforce. In fact, the loss of life caused by alcohol exceeded that due to lung cancer. It is thus recommended that the Joint Health and Safety Committee explore ways in which illness due to alcohol abuse can be prevented. The potential savings in human health and disability would appear to be great.

RECOMMENDATIONS

As a result of the exploratory analysis of mortality among employees of Slater Steels, the following actions are recommended to the Joint Health and Safety Committee:

1) Substantial environmental changes have occurred in the Melt Shop in the past 20 years. It is recommended that the Joint Health and Safety Committee review these changes with Ministry of Labour hygienists to determine if hazardous airborne exposures exist at present. It is suggested that an inventory of airborne contaminants be compiled and examined for the presence of known or suspected cancer-causing agents.

2) It is recommended that an attempt be made to advise current and former Melt Shop workers of the lung cancer risk and to strongly urge them to stop smoking.

3) It is recommended that the Joint Health and Safety Committee explore ways in which illness due to alcohol abuse can be prevented. The potential savings in human health and disability would appear to be great.

4) It is recommended that consideration be given to an expanded study of mortality for the purpose of better defining the lung cancer risk among current and former employees.

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TABLE 1: A COMPARISON OF THE CAUSES OF DEATH OCCURRING AMONG SLATER STEELS EMPLOYEES AND ONTARIO MEN

CAUSE	STATUS	OBSERVED	EXPECTED	PMR
All Causes	R	102		
	A	39		
All Cancer	R	16	23.8	67
	A	12	9.6	125
Lung Cancer	R	6	7.6	79
	A	7	3.3	213
Digestive Cancer	R	4	7.5	53
ICD: 150-159	A	2	2.8	73
Blood and Lymph Cancer	R	2	1.9	105
ICD: 200-207	A	1	1.0	100
Kidney and Bladder Cancer	R	1	1.5	69
	A	2	0.5	425
Circulatory Diseases	R	56	54.9	102
(Heart and Stroke)	A	17	15.9	107
Respiratory Diseases	R	11	8.7	126
(Excluding Cancer)	A	0	1.4	0
Cirrhosis of the Liver	R	4	1.4	284
	A	3	1.6	183
Accidents	R	3	3.5	85
ICD: 800-999	A	6	6.9	87

Definitions: Status = Retired(R) or Active(A);
PMR = Proportional Mortality Ratio

TABLE 2: A COMPARISON OF THE CAUSES OF DEATH OCCURRING AMONG SLATER STEELS EMPLOYEES AND ONTARIO MEN ACCORDING TO MELT SHOP EMPLOYMENT STATUS

CAUSE	STATUS	OBSERVED	EXPECTED	PMR
All Causes	N	108		
	M	23		
All Cancer	N	18	26.0	67
	M	9	5.8	156
Lung Cancer	N	6	8.6	70
	M	7	1.9	361
Digestive Cancer	N	5	8.0	63
ICD: 150-159	M	0	1.7	0
Blood and Lymph Cancer	N	3	2.2	137
ICD: 200-207	M	0	0.6	0
Kidney and Bladder Cancer	N	3	1.5	200
	M	0	0.3	0
Circulatory Diseases	N	62	54.5	114
(Heart and Stroke)	M	5	10.2	49
Respiratory Diseases	N	8	7.9	101
(Excluding Cancer)	M	2	1.2	164
Cirrhosis of the Liver	N	5	2.3	221
	M	2	0.7	272
Accidents	N	6	7.1	84
ICD: 800-999	M	3	3.0	100

Definitions: Status = N: Never Worked in Melt Shop
= M: Employed at Least 1 Day in Melt Shop

TABLE 3: A COMPARISON OF THE NUMBERS OF LUNG CANCER DEATHS BETWEEN MELT SHOP AND NON-MELT SHOP WORKERS

1) Ages at Death 23 to 44:

	Lung Cancer	Other Causes	Total
Ever Melt Shop Worker	0	4	4
Never Melt Shop	0	4	4
Total Number of Men	0	8	8

2) Ages at Death 45 to 64:

	Lung Cancer	Other Causes	Total
Ever Melt Shop Worker	6(55%)	5(45%)	11
Never Melt Shop	4(10%)	35(90%)	39
Total Number of Men	10	40	50

3) Ages at Death 65 to 74:

	Lung Cancer	Other Causes	Total
Ever Melt Shop Worker	1(14%)	6(86%)	7
Never Melt Shop	0(0%)	28(100%)	28
Total Number of Men	1	34	35

3) Ages at Death 75 or More:

	Lung Cancer	Other Causes	Total
Ever Melt Shop Worker	0	1	1
Never Melt Shop	2(5%)	35(95%)	37
Total Number of Men	2	36	38

TABLE 4: ANALYSIS OF THE RISK OF LUNG CANCER ACCORDING TO EMPLOYMENT IN THE MELT SHOP FOR MEN AGED 45 TO 75 AT DEATH

1) ANY EMPLOYMENT VERSUS NO EMPLOYMENT

Relative Risk of Lung Cancer for Men with Any Melt Shop Exposures Compared to Men with No Melt Shop Exposures:

Relative Risk = 6.8 P < 0.02

95% Confidence Interval: [1.3 - 36.7]

2) RISK ACCORDING TO YEARS EMPLOYED IN THE MELT SHOP

	Number of Deaths		
Years in Melt Shop	Lung Cancer	Other Causes	Total
Never Melt Shop Worker	4(6%)	63(94%)	67
Six Months to 5 Years	2(29%)	5(71%)	7
More Than 5 Years	5(45%)	6(55%)	11

Chi-Square Test for Trend:

Chi-Square = 14.5 P < 0.001

Relative Risks (with 90% Confidence Intervals):

Years in Melt Shop	Risk Relative to Unexposed Group
None	1.0
Six months to 5 Years	6.3 [0.78 - 46.2]
More than 5 Years	13.1 [2.8 - 67.0]

TABLE 5: ANALYSIS OF THE RISK OF LUNG CANCER ACCORDING TO EMPLOYMENT IN THE MELT SHOP PRIOR TO AUGUST, 1968 FOR MEN AGED 45 TO 75 AT DEATH

1) ANY EMPLOYMENT VERSUS NO EMPLOYMENT

Relative Risk of Lung Cancer for Men with Any Melt Shop Exposures Compared to Men with No Melt Shop Exposures:

Relative Risk = 8.7 P < 0.01

95% Confidence Interval: [1.8 - 43.1]

2) RISK ACCORDING TO YEARS EMPLOYED IN THE MELT SHOP PRIOR TO INTRODUCTION OF CONTINUOUS CASTING IN JULY, 1968

	Number of Deaths		
Years in Melt Shop	Lung Cancer	Other Causes	Total
Never Melt Shop Worker	5(7%)	65(93%)	70
Six Months to 5 Years	3(38%)	5(62%)	8
More Than 5 Years	3(43%)	4(57%)	7

Chi-Square Test for Trend:

Chi-Square = 11.0 P < 0.001

Relative Risks (with 90% Confidence Intervals):

Years in Melt Shop	Risk Relative to Unexposed Group
None	1.0
Six months to 5 Years	7.8 [1.4 - 45.0]
More than 5 Years	9.8 [1.6 - 61.1]

TABLE 6: WORK HISTORIES OF MELT SHOP EMPLOYEES DYING OF LUNG CANCER

A) Died 1980. Age 72. Exposure 0.75 years. Latency < 15 yrs
Crane Operator (YARD) 1941-1967
Crane Operator (**MELT SHOP**) Oct 15/67-July 16/68
Crane Operator (YARD) July 16/68-Jan 31/72

B) Died 1985. Age 56. Exposure 16 years. Latency 20 yrs
Spare (YARD) Feb 1963-Feb 1964
Crane Operator (Finishing) Feb 1964-Aug 1964
Crane Operator (**MELT SHOP**) Aug 1964-Dec31/84

C) Died 1975. Age 53. Exposure 14 years. Latency 19 yrs
Pitman (**MELT SHOP**) July 1956-Aug 1964
Ladleman (**MELT SHOP**) Aug 1964-July 1965
Trainee Furnace Helper (**MELT SHOP**) July 1965-Oct 1965
Furnace Helper (**MELT SHOP**) Oct 1965-1975

D) Died 1986. Age 58. Exposure 4 years. Latency 20 yrs
General Helper (**MELT SHOP**) Feb 1966-Dec 1966
Pitman (**MELT SHOP**) Dec 1966-May 1968
Labourer (**MELT SHOP**) May 1968-Aug 1968
Tundish Conditioner (**MELT SHOP**) Aug 1968-April 1970
Mould Operator (Continuous Casting) April 1970-Nov 1978
Assistant Ladleman (**MELT SHOP**) Nov 1978-Dec 1978
Mould Operator (Continuous Casting) Dec 1978-1986

E) Died 1983. Age 55. Exposure 10 years. Latency 15 yrs
Switchman and Crane Hooker (YARD) April 1951-Nov 1968
Mould Inspector (**MELT SHOP**) Nov 1968-July 1983

F) Died 1973. Age 62. Exposure 22 years. Latency 28 yrs
Ladleman (**MELT SHOP**) July 1945-1973

G) Died 1981. Age 61. Exposure 25 years. Latency 30 yrs
Pitman (**MELT SHOP**) May 1951-Aug 1963
Furnace Helper (**MELT SHOP**) Aug 1963-Nov 1963
Pitman (**MELT SHOP**) Nov 1963-July 1964
Furnace Helper (**MELT SHOP**) July 1964-1981

TABLE 7: AN ANALYSIS OF THE ASSOCIATION BETWEEN LUNG CANCER RISK AND SPECIFIC JOBS

A) Crane Operator:

	Lung Cancer	Other Causes	Total
Ever Crane Operator	2	3	5
Never Crane Operator	9	71	80
Total Number of Men	11	74	85

Relative Risk (With 90% Confidence Interval): 5.3 (1.2 - 38)

B) Pitman:

	Lung Cancer	Other Causes	Total
Ever Pitman	3	0	3
Never Pitman	8	74	82
Total Number of Men	11	74	85

Relative Risk (With 90% Confidence Interval): Cannot be calculated because all 3 men who worked as Pitmen died of lung cancer

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C) Ladleman:

	Lung Cancer	Other Causes	Total
Ever Ladleman	3	2	5
Never Ladleman	8	72	80
Total Number of Men	11	74	85

Relative Risk (With 90% Confidence Interval): 13.5 (1.9 - 110)

D) Furnace Operator:

	Lung Cancer	Other Causes	Total
Ever Furnace Operator	2	1	3
Never Furnace Operator	9	73	82
Total Number of Men	11	74	85

Relative Risk (With 90% Confidence Interval): 16.2 (1.3 - 83)

PROPORTION OF DEATHS FROM LUNG CANCER AGES 45 to 74

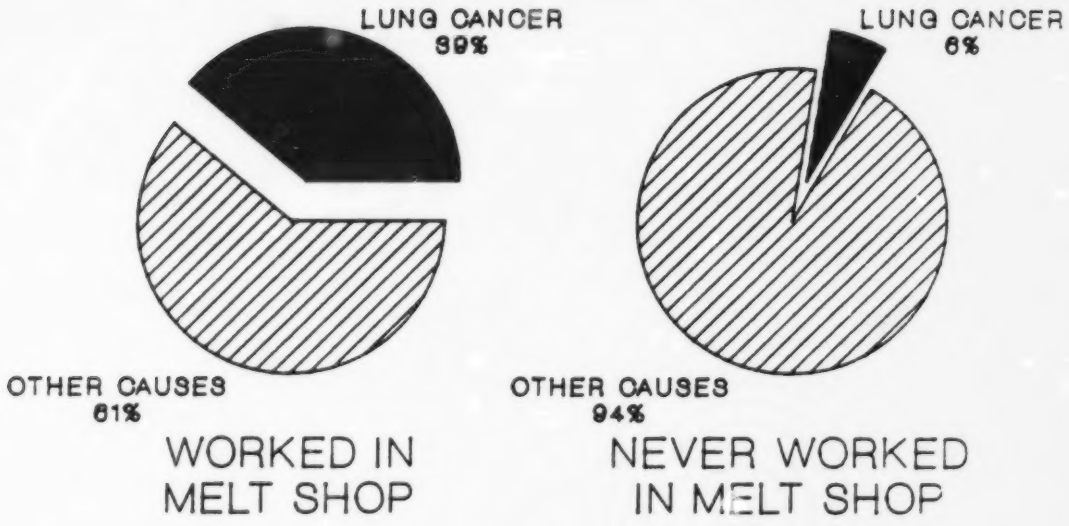

FIGURE 1